SCIENCE ABSTRACTS.

Section A.—PHYSICS.

DECEMBER 1921.

GENERAL PHYSICS.

1957. *The Marvin Pyrheliometer: Calibration and Behaviour.* **P. D. Foote.** (Bureau of Standards, Bull. 14. pp. 605–635, July 12, 1919.)—For the first time, it is believed, a pyrheliometer has been calibrated by two methods, the usual electrical method and a radiometric method. In the radiometric method a known quantity of radiation from a black body was allowed to fall upon the pyrheliometer receiver in exactly the same manner as when employed for solar measurements. The calibrations by the two methods agreed within limits of experimental error, if the Stefan-Boltzmann constant were chosen as $\sigma = 5\cdot7 \times 10^{12}$ watts cm.$^{-2}$ deg.$^{-4}$, the latest and most accurate determination of this constant of total radiation. Or conversely, the constant has been observed as $5\cdot7 \times 10^{-12}$ within an accuracy of possibly 5 %.

The behaviour of the Marvin pyrheliometer has been carefully investigated. A lag, part of which is due to the galvanometer of the bridge, has been found to exist, and, for the silver disc No. 3, was experimentally shown to be less than 2 secs. Both theoretically and experimentally it was shown that the effect of this lag is negligible after 5 to 10 secs. The cooling and heating of the receiver follows Newton's law of cooling.

In order completely to eliminate errors due to a lag effect, readings should be made at 10 secs. and 60 secs. following the beginning of a heating or cooling. The factor for converting readings of temperature or resistance-change over this 50-sec. interval to corresponding changes over a complete 60-sec. period is 1·217. This factor is the same for both electrical and radiometric heating, and was determined with an accuracy of 0·1 %.

A Marvin pyrheliometer calibrated by two methods, electrical and radiometric, was compared by solar observations with the United States Weather Bureau Smithsonian standardised pyrheliometer "S. I. No. 1," calibrated by comparison with the Smithsonian primary standard water-flow pyrheliometer. The Marvin pyrheliometer thus calibrated gave 2 % lower values of the solar radiation than the Smithsonian pyrheliometer. This difference is within the errors of observation of the present calibration. **Author.**

1958. *Measurement of Variable Velocities in Gas Streams.* **K. Schreber.** (Zeits. techn. Physik, 2. No. 4. pp. 106–110, 1921.)—For the complete investigation of a machine with closed combustion chamber the quantities of gas and air introduced must be known. Exact measurements are rendered difficult by the impact character of the motion, and only small machines have so far been examined. The author now submits a new method of approach. Experimental work is described in great detail in connection with the formula $G = \mu f \sqrt{(2gvh)}$, where G is the outflow gas, f the cross-section of the nozzle opening, g the acceleration due to gravity, h the height of the gas column produced by the outflow pressure, ν the specific gravity of the gas, and μ the nozzle number, which is determined by special experiments. When the gas does not flow continuously, but intermittently according to any given law, the nozzle number varies, and the author investigates his assumption of $\mu' = \nu\mu$, where μ' is the new nozzle number and ν the determining factor. The evaluation of ν is a most important technical problem. Experiments indicate that ν is independent of the size and species of nozzle, but appears related to the time sequence of the impacts. The paper contains several diagrams and curves, and abounds in technical detail. The paper of Seeliger and Lintow should be consulted [see Abs. 340 (1921)]. H. H. Ho.

1959. *Cyclic Motion of a Liquid about a Solid Moving Parallel to a Rectilinear Partition.* **D. Riabouchinski.** (Comptes Rendus, 173. pp. 25–26, July 4, 1921.)—From the general equations of motion of a solid body in an incompressible liquid as developed by W. Thomson, the conditions obtaining when the solid moves with uniform velocity are mathematically expressed (Joukovski's theorem). The case where the section of the solid is a circle of given radius with its centre at a given distance from the partition is investigated mathematically. A. B. C. L.

1960. *Hydraulic Paradox in Venturi Meter.* (Engineering, 111. pp. 639–640, May 27, 1921.)—It has been found in experiments with orifices of the Venturi type that flows in excess of the theoretical maximum may be obtained. This cannot be explained on the assumption that the flow at the inlet is viscous, while that at the throat is turbulent, since the anomaly is found in cases where it is known that the inlet flow is turbulent. The author suggests that the departure from the theoretical result is due to variations in the head needed for the reversal of the radial velocities of the fluid particles, since there is no justification for the assumption that this head is the same at all positions along a pipe of varying section. J. W. T. W.

1961. *Gliding Flight of Birds.* **Idrac.** (Comptes Rendus, 172. pp. 1161–1164, May 9, 1921.)—A continuation of previous work on this subject [see Abs. 670 (1920)]. The author finds from temperature measurements at different heights in regions of the air where soaring flight takes place, that there is always an upward component in the wind due to temperature gradient; the mean value of the upward velocity due to this temperature gradient is found to be about 1 m. per sec. Curves are given in the paper to exhibit the variations of temperature gradient and the coincidence of high gradients with the periods at which soaring flight was observed. This explanation of soaring flight cannot, however,

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apply in the case of the albatross or other examples of such flight in cold regions. J. W. T. W.

1962. *The Fundamental Hypotheses of Physics and Geometry.* **E. Borel.** (Comptes Rendus, 173. pp. 189–191, July 25, 1921.)—The author attempts to define the fundamental physical hypotheses implied in all the theories which attempt a synthesis of geometry and physics. The essential ideas have been put forward by Riemann and by Poincaré, and it is only necessary to apply them to Lorentz and Einstein's interpretation of experimental facts. Only three-dimensional space considered at a given instant is treated, but similar considerations can be applied to the four-dimensional universe. The first hypothesis put forward assumes that it is possible to define in three-dimensional space a network of coordinates u, v, w with local continuity. It is not possible or necessary to imagine an infinite number of surfaces $u =$ constant traced; since there is continuity it is possible to interpolate where necessary. The form of the network is connected with that of the whole space, considered from the point of view of the *analysis situs*. The second hypothesis is that if an infinitely small gauge is placed at any point in space, and one end is kept fixed, the locus of the other end is an ellipsoid in the system of coordinates du, dv, dw. Then $ds^2 = \lambda^2\phi(du, dv, dw)$, where ϕ is a quadratic expression, with variable coefficients, corresponding to the ellipsoids for the different points, and λ is an arbitrary factor, depending on the varying length of the gauge at different points of space. The coefficients of the above equation must be supposed continuous. It is permissible, if necessary, to add to these three physical hypotheses a geometrical hypothesis, by defining $d\sigma^2 = \psi(du, dv, dw)$, where ψ is a quadratic expression with continuous coefficients. This may or may not give a simpler form to the physical properties of the universe. It will probably prove best, however, in the first instance to examine the first three hypotheses closely, and particularly to find out if they remain true on the molecular scale, or if they are only true statistically. H. N. A.

1963. *Field and Matter.* **H. Weyl.** (Ann. d. Physik, 65. 6. pp. 541–563, Aug. 30, 1921.)—This paper deals with the author's extension to the relativity theory. The Galileo law of inertia shows that a kind of directivity is present in the world which necessitates a definite motion being possessed by a body moving in a definite direction inalterable except by external forces. Einstein has demonstrated the unity of inertia and gravitation, and the Einstein and Galileo conceptions are compared. The physical success of Einstein's conception consists in his directivity field, including the phenomena of gravitation, and requiring no special gravitational force as in the Newtonian theory. A separation of the field into the two components of inertia and gravitation is shown to be without objective significance. The connection between the field laws and matter is discussed at length, and is followed by an investigation of the field formula for the static electron. According to the relativity theory the time and space units are not independent, the only original units being length and quantity of electricity; the gravitational constant k is an equivalence number for the transformation of mass into energy, and its physical significance lies in the fact that the mass loss of a radiating body is equal to k times the emitted energy, and has the dimension l^2/e^2. The second conception of Einstein's theory is next discussed, namely, that matter itself is not all-pervading, but has a definite spacial existence, and may be characterised by field effects. The two following grounds are put forward by the author as telling for the agent and against the field theory of matter: (1) It stands in agreement with the fundamental experience of daily life and of physics, that matter produces the field and that all acts in the world are primarily concerned with matter; (2) the extended relativity theory allows no scope for such generalisation and extension of the classical field laws as Mie has proposed in the case of the special theory of relativity.

The paper is a combination of mathematical and philosophical exposition. H. H. Ho.

1964. *The Principle of Projective Covariance.* **I. Maizlish.** (Phys. Rev. 18. pp. 1–12, July, 1921.)—The principle here presented asserts that the laws of physics are covariant with respect to the following transformation: $x_c = G(\sigma, r)x$, $y_c = G(\sigma, r)y$, $z_c = G(\sigma, r)z$, $t_c = G(\sigma, r)t$, where x, y, z, t are the Minkowski variables, r is the distance of a point in S_4 from the origin of a system of coordinates, and σ is an arbitrary constant. It is shown that if Ψ is a physical quantity depending only upon a single variable ξ, the relation between Ψ and ξ is $\Psi = K\xi^{\alpha/\beta}$, where $\Psi_c = G^{\alpha}(\sigma, r)\Psi$, $\xi_c = G^{\beta}(\sigma, r)\xi$, and K = constant. Examples are given of the application of the principle.

Comparison with the Principle of Similitude.—While there are similarities between the present work and Tolman's, the Principle of Projective Covariance does not in any way depend on the Principle of Similitude. It is pointed out that the principle of similitude, however, may be regarded as a very special interpretation of the principle here presented. Concepts like "miniature universe" are shown to be extraneous, and, by taking a special form of the principle of projective covariance, it is shown that the latter may be so interpreted as to give us also an extended universe.

AUTHOR.

1965. *Crystalline Structure of Bismuth.* **R. W. James.** (Phil. Mag. 42. pp. 193–196, July, 1921.)—The author gives the results of his experiments to determine the crystalline structure of bismuth. He finds, as would be expected, that it has a similar structure to that of antimony previously examined [see James and Tunstall, Abs. 774 (1921)]. The structure is shown to be of the face-centred lattice type, whilst the number of Bi atoms in the unit face-centred rhombohedron is exactly eight, indicating that the unit of the structure contains two interpenetrating face-centred lattices, since a single lattice will contain four atoms only. The length of the edge of the unit structure is found to be $3 \cdot 28 \times 10^{-8}$ cm.

A. B. W.

1966. *Crystalline Structure of Antimony and Bismuth.* **A. Ogg.** (Phil. Mag. 42. pp. 163–166, July, 1921.)—The experiments now described confirm the conclusions of James and Tunstall [Abs. 774 (1921)] that the unit rhomb of antimony contains 8 atoms, that the length of the edge of the unit rhomb is 6·20 Å.U., and that the structure consists of two interpenetrating face-centred lattices. The spacings of the planes, which differ somewhat from those given by James and Tunstall, are indicated diagrammatically in the paper. The shortest distance between the centres of two atoms is 2·92 Å.U. The unit rhomb of crystalline

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bismuth also contains 8 atoms [see preceding Abs.], the length of the edge of the rhomb being 6·52 Å.U. The spacings of one of the face-centred lattices have been calculated. A. B. W.

1967. *Crystal-formation in Vapour Molecules.* **R. Gross** and **M. Volmer.** (Zeits. f. Physik, 5. 2 and 3. pp. 188–191, 1921.)—The paper refers to a directive effect existing in a cylindrical vessel containing molecules of vapour (*e.g.*, mercury vapour at an elevated temperature). By repeated molecular reflections from the walls of the containing vessel it is shown that the vapour molecules may become orientated in a certain direction, and thus function as a regular form of crystal. A. B. W.

1968. *Some Dimensions of the Atom.* **L. S. C. Broughall.** (Phil. Mag. 41. pp. 872–876, June, 1921.)—Van der Waals' equation makes it possible to calculate the following atomic diameters for the inert gases, each number to be multiplied by 10^{-8} to reduce to centimetres: helium 2·30, neon ——, argon 2·86, krypton 3·14, xenon 3·42. The difference between successive values is constant and equal to $0{\cdot}28 \times 10^{-8}$ cm., assuming the diameter of the neon atom to be $2{\cdot}58 \times 10^{-8}$ cm.

Moseley found, in 1913, that the number of electrons in the atom is equal to the atomic number of the element, and Langmuir [see Abs. 991 (1919)] has shown that for the inert gases the atomic numbers are

$$N = 2(1^2 + 2^2 + 2^2 + 3^2 + 3^2 + 4^2).$$

Thus for helium $N = 2(1)^2$, for neon $N = 2(1^2 + 2^2)$, and so on. In order to explain the valencies and magnetic properties of these elements Langmuir suggested that each of the terms in the above equation represents a complete shell of electrons, and the above figures support his views with regard to the distance of these shells from one another. In the case of the inert gases the outer shell is always complete, there is no tendency to acquire other electrons and the valency is therefore zero. Other elements may have a similar structure, but the outer shell is incomplete, and the valency is given by the number of electrons which must be gained or lost to produce the stable structure peculiar to the inert gases. Boron, for example, with the atomic number 5, may consist of a positive nucleus, two electrons corresponding to those of the helium atom, and a ring of three electrons in the shell corresponding to the neon shell. The diameter should be the same as that of the neon atom, or $2{\cdot}58 \times 10^{-8}$ cm. Beryllium (glucinum) has the atomic number 4; two of its electrons may be taken as being at opposite ends of a diameter, the length of which is $2{\cdot}30 \times 10^{-8}$ cm., and two at opposite ends of a diameter $2{\cdot}58 \times 10^{8}$ cm. long at right angles to this. In order that one of these electrons may be in equilibrium, under the repulsive forces of the other three electrons and the attractive force of the positive nucleus, assuming the inverse square law to hold for such short distances, the charge on the nucleus must be 1·08*e*. For lithium, with the atomic number 3, the positive charge on the nucleus is calculated as being $E = 0{\cdot}83e$. Similarly for helium, with two electrons at opposite ends of a diameter, $E = 0{\cdot}25e$. These values are calculated on the assumption that there is no relative motion of the electrons and the nucleus. Difficulties arise when the atomic number is increased to any extent. H. N. A.

1969. *Stability of Atoms.* **E. Rutherford.** (Phys. Soc., Proc. 33. pp. 389–394, Aug., 1921.)—The paper is a summary of recent experimental work relating to the theory of atomic structure. After a brief synopsis of the history of the subject, the author deals with his preliminary experiments, which indicate the possibility of artificial disintegration of some of the ordinary non-radioactive elements. The method employed is that of bombardment by α-particles. High-speed α-particles are fired into the element under consideration, a small proportion of these α-particles colliding with the nuclei of the atoms of the element. If the collision is sufficiently close the nuclei are disintegrated, swift "H" (hydrogen) atoms being "emitted." The author has carefully investigated the circumstances affecting the production of these high-speed hydrogen atoms, and has determined the proportion of the α-particles which produce them, namely, about 1 in 10^6. An explanation is offered for the apparent difference of this ratio from that obtained by Shimizu, viz. 1 in 300, by another method of investigation. A. B. W.

1970. *Diameter of the Atom; Remarks on Rankine's Results.* **W. H. Westphal.** (Zeits. f. Physik, 4. 2. pp. 254–256, 1921.)—Remarks on a paper by A. O. Rankine [Abs. 1666 (1921)] in which atomic diameters for the rare gases and the halogens are determined from W. L. Bragg's X-ray crystal observations and from viscosity data. A. B. W.

1971. *Crystal Structure of Silver Halides.* **R. B. Wilsey.** (Phil. Mag. 42. pp. 262–263, Aug., 1921.)—The crystal structure of the silver halides has been studied by the powder method of Debye and Scherrer [Abs. 1130 (1916)]. Following the procedure of Hull (Phys. Rev. 9. pp. 84–87, 1917), the authors isolated the K_α radiation of molybdenum ($\lambda = 0{\cdot}712$ Å.) and allowed it to fall on the powdered sample spread in a thin layer upon a ribbon of dry mounting tissue. The diffraction pattern was received upon a film bent into semicircular form. Comparison of experimental results with W. L. Bragg's theoretical "atomic diameters" [Abs. 21 (1921)] is given in the following table:—

Substance.	Arrangement of Atoms.	Side of Elementary Cube Å.U.	Distance apart of Nearest Atomic Centres observed.	Computed from Bragg's Atomic Diameters.
Silver chloride	Simple cubic	2·78	2·78	2·82
Silver bromide	Simple cubic	2·89	2·89	2·96
Silver iodide	Tetrahedral	6·53	2·83	3·17

The silver halides were precipitated from $AgNO_3$ by the corresponding potassium halides; this giving a flocculent precipitate in which the crystal particles are too small to be recognisable under the microscope. The X-ray analysis gives a direct proof that these precipitates are crystalline.

The powder photograph of fused silver bromide gives the same diffraction pattern as the precipitated salt. A. B. W.

1972. *Coalescence of Liquid Spheres; Molecular Diameters.* **W. Taylor.** (Phil. Mag. 41. pp. 877–889, June, 1921.)—The author has studied the action of two spheres of the same liquid, when near to each other and when they come into contact, and has not been able to find any direct evidence that they attract each other, no matter how small they are, down to microscopic dimensions, nor how closely they approach, so long as they do not touch. When contact takes place surface tension at once causes the two masses to coalesce and become one sphere. It is suggested that the action between molecules is of the same nature; that there are no molecular attractions, but that when two molecules come into contact they may be caused to unite by a force (or agent) of the same nature as the surface tension of larger masses of the liquid, just as if there were a surface tension (imaginary of course) over the surface of each molecule.

If a large number of liquid spheres coalesce into one mass the potential surface energy before coalescence will be $Tn\pi d^2$, and afterwards $T\pi D^2$, where T is the surface tension, n the number of spheres, d the diam. of each of them, and D the diam. of the resulting large sphere. The difference, or $T\pi(nd^2 - D^2)$, is the amount of potential energy which has been changed into heat in the process; this may be written $T\pi D^2(n^{1/3} - 1)$. If n is large this differs very little from $T\pi D^2 n^{1/3}$, which may be written $(36m^2\pi/\rho^2)^{1/3}Tn^{1/3}$, where m is the total mass, which may be taken as the mass of a gm. molecule, *i.e.*, the molecular weight, in which case n is the number of small spheres in a gm. molecule. Assuming that surface tension acts even for the coalescence of the molecules $T(36\pi m^2/\rho^2)^{1/3}n^{1/3} = mLJ$, where L is the latent heat of vaporisation and J is Joule's constant, n being now the number of molecules in 1 gm. mol. D. L. Hammick [see Abs. 403 (1920] has, using a more complicated hypothesis, arrived at a result which is really identical with the above, and has made calculations for 29 substances, which show good agreement between theory and fact. Einstein [see Abs. 1239 (1901)] has put forward the view that the surface energy of a liquid is of the nature of potential energy, and is expressible by an equation, one of whose terms depends on the atomic weight. The author's formula may be written $LJ = T(36\pi N/m\rho^2)^{1/3}$; T is the energy per cm.^{2} assumed to exist on the surface of the molecules. Since the molecular tension $Tm = T_0 = 133{\cdot}6$ in the case of water, by taking for the latent heat $L = 498$, which is the value after correcting for external work, $\rho 0 = \rho 277 = 1$ and $m = 18$, the value of N can be calculated as $6{\cdot}05 \times 10^{23}$. Millikan's value for this number is $6{\cdot}065 \times 10^{23}$, and Perrin's $6{\cdot}86 \times 10^{23}$. Let these N molecules unite in pairs, the pairs unite in groups of four, and so on until all are united in a single mass; then p distinct acts of coalescence will be required per gm., where $2^p = N/18$ and p is therefore 75. The following values of the energy changed into heat at the different steps shows that the final stages are not very important from this point of view:—1st step, $E = 102{\cdot}6$ cals.; 2nd, $E = 81{\cdot}4$; 3rd, $E = 64{\cdot}6$; 21st, $E = 1{\cdot}0$; 75th and final step, $E = 0{\cdot}00000385$ cals. After the 5th step $340{\cdot}5$ cals. of heat have been produced, or 68 % of the whole latent heat. After the 21st step the total surface energy remaining is only $3{\cdot}91$ cals., or considerably less than 1 % of the original amount. Similar calculations have been made for nine other substances. The value $0{\cdot}21$ obtained for $N/10^{23}$ in the case of mercury suggests that, when L was determined by Young in 1910, the vapour consisted of undissociated molecules. Ether, chloroform, nitrogen, oxygen, and benzene also give values considerably less than that for water.

It is also possible to calculate the diameter of the molecule from the above data. For water the diameter of the molecule at 0° abs. is $d_0 = 3 \cdot 85 \times 10^{-8}$. H. N. A.

1973. *Supply of Energy from and to Atmospheric Eddies.* **L. F. Richardson.** (Roy. Soc., Proc. 97. pp. 354–373, July 1, 1920.)—*Criterion of Turbulence.*—The energy E′ of atmospheric eddies contained in a mass of atmosphere, *i.e.*, the kinetic energy associated with the departures of the velocity from the mean, is supplied partly from (or to) the mean wind, the eddy-stresses doing work upon the corresponding rates of mean strain and partly, associated with convection, from (or to) the intrinsic energy of the mass. Accompanying a change of intrinsic energy is a change of gravitational energy on account of the rising or sinking of the atmospheric column, and this cannot be neglected. At the same time there is a dissipation of eddying kinetic energy by molecular viscosity. To obtain an idea of the rate at which this dissipation takes place, a particular case is investigated in which the linear dimensions of the eddies are of the order of 10 m., when the eddy energy is found to be reduced to 0·8 of its value in a period of 24 hours. The rate at which intrinsic and gravitational energy are together transformed into eddy-energy is $-\partial\sigma/\partial h \times cg/\gamma_p$, where c is the eddy-conductivity, γ_p the thermal capacity per mass at constant pressure, and $\partial\sigma/\partial h$ the up-gradient of entropy-per-mass. Inserting mean values for the height of 1 km. this rate is 10^{-2} erg sec.$^{-1}$ cm.$^{-3}$ expressing the convective activity per volume lost by the eddies.

Combining the various supplies and considering the continuity of energy in a column of dry atmosphere on a large base, an expression is found for the time-rate of E′, from which a number of interesting conclusions may be drawn. Considering a slightly turbulent atmosphere the criterion as to whether the eddy energy will increase is seen to be $(\partial\bar{v}_x/\partial h)^2 + (\partial\bar{v}_y/\partial h)^2 > g/\gamma_p \cdot \partial\sigma/\partial h$, where $\bar{v}_x$ and $\bar{v}_y$ are the horizontal components of the mean wind. Inserting mean values it appears that the usual places for eddies to be generated are in the first few hundred metres above the surface and at the base of the stratosphere. The stability of the stratosphere itself follows from the large positive value of $g/\gamma_p \cdot \partial\sigma/\partial h$ applicable to it. The dying away of the surface wind at night, when the day wind is not too strong, is also explained, for the effect of radiation is to increase $\partial\sigma/\partial h$. When the day wind is strong, however, $(\partial\bar{v}/\partial h)^2$ is large enough to maintain the above inequality and eddies persist, supplying momentum to the surface air. A rough test of this is obtained by comparison with observations at Benson, Oxfordshire.

Eddy Thermodynamics.—The conception of an "eddy-heat-per-mass" is introduced, defined as $\Theta = \frac{1}{2}\overline{(v_x'^2 + v_y'^2 + v_H'^2)}$ where v_x' etc., are the components of the deviation of the velocity from the mean, and the bar denotes a mean value. This is related to the "eddy-pressure" p, defined as the negative mean of the three direct tractions, by $p = \frac{2}{3}\rho\Theta$, ρ being the density, a relation resembling the gas equation. It is then shown that $\rho^{2/3}/\Theta$ is constant following the mean motion so that, in a way analogous to the adiabatic cooling of a gas, the eddy-heat-per-mass is diminished by a mean expansion. In proving this, however, it is assumed that there is no diffusion of eddy-energy. This is briefly touched on in the concluding section where a distinction is drawn between true diffusion of eddy-heat-per-mass due to the wandering of individual eddies, and large eddy-diffusion of small-eddy-heat-per-mass as when a cumulus eddy raises thousands of smaller ones. In the latter case it is shown that the "potential-eddy-heat-per-mass" defined by $\chi = \Theta(\rho_i/\rho)^{2/3}$ where ρ_i is some standard density, will diffuse according to an equation $\partial\chi/\partial t = -\partial/\partial p\,.\,(\xi_1\partial\chi/\partial p)$ of the same form as that applicable to ordinary potential-temperature [see Abs. 1360 (1919)] provided we are only concerned with changes of eddy-energy additional to these considered in the first part of the paper. M. A. G.

1974. *Some Measurements of Atmospheric Turbulence.* **L. F. Richardson.** (Roy. Soc., Phil. Trans. 221. pp. 1–28, June 9, 1920.)—The author [see Abs. 1360 (1919)] has previously extended Taylor's original theory of eddy-diffusion to take account of height-variations of air density ρ and turbulence, and in so doing was led to a measure of turbulence ξ, called the turbulivity, and defined by the equation $\partial\chi/\partial t = \partial/\partial p\,.\,(\xi\partial\chi/\partial p)$, where p is the pressure used as a measure of the height h, and χ is the diffusing quantity. χ must satisfy certain conditions, but may be water-per-mass of atmosphere, potential temperature (but not entropy-per-mass), or horizontal momentum in a fixed azimuth. In the last case $\xi = g^2\rho\mu$, where μ is the eddy-viscosity defined as (eddy-shearing stress)/(rate of mean shearing strain). There is a further measure of turbulence, the eddy-conductivity c, defined by $\partial(\rho\chi)/\partial t = \partial/\partial h\,.\,(c\partial\chi/\partial h)$ and related to ξ by $\xi = g^2\rho c$. Neglecting variations with height, ξ is related to Taylor's K, the eddy-diffusivity, by $\xi = g^2\rho^2\mathrm{K}$.

In the present paper the author develops a mathematical theory by which numerical values for these measures of turbulence may be obtained by observing the scattering of smoke or floating bodies such as thistle-down, released at a fixed point. In the case of the diffusion of potential temperature the method differs according as the eddies are due to "dynamical instability," on the one hand, or to variations of potential temperature, such as are cumulus eddies, on the other. The scattering of smoke may also be made to yield values of the eddy-stresses, both direct and tangential, and the eddy-viscosity is then best obtained from the above definition. The eddy-stresses and diffusivity may also be deduced by following the irregularities in the motion of a particular small portion of air for a sufficient time. This has been done by observing shell-bursts or portions of cloud or a small pilot-balloon eliminating the uniform vertical motion and thus obtaining the deviations. The eddy-shearing stresses and eddy-viscosity and the shearing stress on the ground are also deducible from upper-wind observations. Values of ξ have already been obtained from considerations of precipitation (*loc. cit.*).

Numerical Values.—The observed eddy-shearing stresses on a land surface range from $0{\cdot}7 \times 10^{-3} \times \bar{m}^2/\rho$ to $0{\cdot}7 \times 10^{-2} \times \bar{m}^2/\rho$, where $\bar{m}$ is the mean momentum-per-volume in the first km. above the ground. The eddy-viscosity deduced from upper-wind observations at Lindenberg is found to increase with height and, except near the surface, the air is considerably more viscous across the wind than along it. Numerical values of the stresses and diffusivity, obtained by the various methods, are collected in a table which shows a range in the value of ξ from $7\ g^2\,\mathrm{cm.}^{-2}\,\mathrm{sec.}^{-5}$ near a tall-grass surface, to $1{\cdot}4 \times 10^5$, on another occasion, at the height of a factory chimney. Observations of rising cumuli in calm weather yielded a value of ξ, in the sense of friction, of the order of 10^6, extending the observed range from 7 to a million. To estimate the diffusivity for potential temperature in this last case a knowledge of the lapse rate of temperature in and between the cumuli would be required. The above values of ξ may be contrasted with the value $0\cdot 2$ appropriate to perfectly still air in a laboratory. ξ increases both with velocity and with height, at least up to a point between 100 and 1000 m. above which a marked decrease occurs. M. A. G.

1975. *Determination of the Seismic Hypocentre.* **E. Oddone.** (Accad. Lincei, Atti, 29. i. pp. 458–462, June, 1920.)—From elastic theory the author arrives at a simple equation for the time of oscillation, T, of a stratum of thickness 2ϵ equal to the depth of the hypocentre. Assuming for e, E, and V (respectively the density, Young's modulus, and the velocity of the surface wave) the values 3, 2×10^{12} and $3\cdot 5$ km./sec., the equation is $2\epsilon = 2\cdot 26 \times 10^4 T$. The method presupposes that the epicentral distance is about 10,000 km. Application of the formula shows that for a seism at a depth of 9 km. no wave longer than 40 secs. will be observed, and for a seism at 13-km. depth no wave of longer period than 60 secs. The Messina earthquake gave waves of 40 secs. period at Zi-ka-wei in China, indicating that the depth of the hypocentre was 9 km. L. H. W.

1976. *Focal Depth of Earthquakes.* **G. W. Walker.** (Roy. Soc., Phil. Trans. 222. pp. 45–56, Aug. 5, 1921.)—The calculation of the speed of propagation of an earthquake wave is made on the assumption that the focus lies near the surface. Galitzin's observations at Pulkovo, on the angle of emergence of the shock, suggest that the focus is at a depth of something like one-fifth of the earth's radius. If this be true, then important modifications will have to be made both in the interpretation of seismograms and in the determination of the dependence of speed on depth. The depth of focus can be tested in two ways: (*a*) by the examination of seismograms for depths greater than 11,000 km., and (*b*) by measuring the angle of emergence of S-waves by means of three component seismometers. W. A. R.

1977. *Application of Dicyanin to the Photography of Stellar Spectra.* **P. W. Merrill.** (Bureau of Standards, Bull. 14. pp. 487–505, 1919.)—1. Fraunhofer's A band (wave-length $0\cdot 760\mu$) and a considerable region of greater wave-length have been photographed in numerous stellar spectra by means of plates sensitised with dicyanin.

2. A strong band at $0\cdot 760\mu$, nearly coincident with A, has been discovered in spectra of Class M. It is very marked in Mb and Md spectra, and may be useful for purposes of classification.

3. The titanium arc shows flutings near this wave-length, which probably correspond to the stellar bands.

4. In spectra of Class N, bands at $0\cdot 692\mu$, $0\cdot 708\mu$ ($0\cdot 723\mu$) have been observed, which may be identical in origin with bands in the so-called cyanogen spectrum.

5. On dicyanin plates, spectra of Class R are strikingly dissimilar to those of Class N in spectral distribution of energy.

6. The greatest wave-lengths observed appear by extrapolation to be about $0\cdot 87\mu$.

7. General conclusions may be stated as follows: (*a*) Many stellar

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spectra possess sufficient intensity in the region of wave-length 0·80 μ (infra-red) to enable this portion of the spectrum to be photographed on plates sensitised with dicyanin ; (*b*) in favourable instances stellar spectra can be well observed to 0·85 μ, or possibly to even greater wave-lengths ; (*c*) the region of stellar spectra of greater wave-length than 0·70 μ contains features of importance, especially in the case of the later types. AUTHOR.

1978. *Jupiter's Four Great Satellites.* **W. de Sitter** and **A. J. Leckie.** (Leyden Obs., Ann. 12. Pts. 1 and 2. Nature, 107. p. 663, July 21, 1921.—Abstract.)—These were published in 1918 and 1919, before Sampson's theory appeared in print. De Sitter uses a new intermediary orbit, substituting the great periodic inequalities for the eccentricity of the Keplerian ellipse. He finds for the masses, 3796, 2541, 8201, and 4523, in hundred-millionths of Jupiter's mass, or 0·985, 0·659, 2·128, and 1·173 times the moon's mass. Using the diameters measured by the interferometer (1″·00, 0″·905, 1″·325, and 1″·31), the densities come out 0·853, 0·788, 0·811, and 0·462 that of the moon. The adjusted final values of mean daily motions of I, II, and III referred to first point of Aries are 203°·4889928, 101°·3747618, and 50°·3176463. W. W. B.

1979. *The Multiple System ξ Ursæ Majoris.* **G. Abetti.** (Soc. Spettroscop. Ital., Mem. 8. pp. 105–116, Oct.–Nov.–Dec., 1919.)—The author has collected all the observational material for the interval 1895 to present date, and gives tables showing the position angles and distance, and the deviations from the orbits of See and of Nörlund ; further, graphs of the amplitude of the angular velocities of the A and B components for that interval. The mean period works out at 2·30 years. Although sufficient data are not yet available for a satisfactory determination of the spectroscopic orbit, the period of component A is suspected to be < 10 days. An attempt has been made to estimate the relative mass of the A, *a* system ; the ratio of the masses is found to be : $m_A/m_a = 2\cdot4$. L. H. W.

1980. *Relationship of Absolute Magnitude to Space-Velocity.* **W. S. Adams, G. Strömberg,** and **A. H. Joy.** (Mt. Wilson Observat. Contrib. No. 210. Astrophys. J. 54. pp. 9–27, July, 1921.)—*Variation of the Velocity of Stars with Absolute Magnitude.—A statistical study* of the radial, tangential, and space-velocities of 1350 stars, mostly of types F, G, K, and M, shows a marked correlation with absolute magnitudes. The results are given in the form of equations and tables. The increase in average space-velocity for a decrease of one magnitude in brightness varies with the type, but is of the order of 3 km./sec. The greater homogeneity of the giant stars as a class and their comparative freedom from large individual motions are indicated by the results. As would be expected for a random distribution of velocities as to direction, the average radial velocities are about half the corresponding average space-velocities.

The frequency of the space-velocities of stars cannot be represented by a distribution according to Maxwell's law, for there is a large excess of stars with high velocities, but a type of *frequency function* based upon the assumption of a normal error-distribution in the logarithms of the velocities is found to represent the observations much more closely. The function is proportional to $e^{-h^2(\log v - \log \bar{v})^2}$, where $\bar{v}$ is the geometrical mean space-velocity. AUTHORS.

LIGHT.

1981. *Conditions of Emission of Spark Lines by the Electric Arc.* **A. de Gramont** and **G. A. Hemsalech.** (Comptes Rendus, 173. pp. 278–283, Aug. 1, 1921.)—Visual observation of the d.c. arc between fairly large metal electrodes has revealed the existence of two classes of spark lines in the arc: (i) lines appearing permanently in the spectrum; (ii) lines appearing momentarily. These latter show themselves at the positive electrode at the moment of starting the arc. Experiments here described show that the spark lines are always emitted when the current of the electric arc has to traverse media (vapours or gas) which possess a relatively feeble degree of ionisation, that is, which offer a great resistance to the passage of an electric current. It is concluded that the emission of spark lines is closely related to the existence of intense electric fields, for the spark lines are only emitted when the distance between the electrodes is very small. [See Abs. 253 and 576 (1920).] A. W.

1982. *Law of Absorption of Caesium Lines.* **C. Füchtbauer** and **H. Bartels.** (Zeits. f. Physik, 4. 3. pp. 337–342, 1921.)—Füchtbauer and Hofmann, during work on the absorption of series lines, found that the absorption coefficients at the place of max. absorption for the caesium doublet λλ4593, 4555 had the ratio $1 : 3 \cdot 05$ [Abs. 230, 1914)]. The corresponding ratio for the sodium D-lines was found by Füchtbauer and Schell [Abs. 229 (1914)] to be $1 : 2 \cdot 03$. From these and later results the following series law has been formulated:—For corresponding doublets of all the principal series of the alkalies, the intensities of the long-wave and of the short-wave lines have a definite ratio, and this ratio for the pair $(1 \cdot 5s - mp)$ is equal to $1 : m$. A method is described for estimating the density of caesium vapour by absorption measurements. The caesium lines λλ3617 and 2613 correspond to $(1 \cdot 5s - 5p)$, and measurements at different temperatures gave for the ratio the values $5 \cdot 00$ and $5 \cdot 23$. Measurements of the half-value breadth of the line λ3612 showed that it was $3 \cdot 5$ to 4 times that of the line λ4555, which is one of the pair $1 \cdot 5s - 3p$. This is in agreement with the frequently observed qualitative result, that the breadth of series lines increases rapidly with the term number. [See Abs. 1424 (1920).] A. W.

1983. *Spark Spectra in the Extreme Ultra-Violet.* **L.** and **E. Bloch.** (J. de Physique et le Radium, 2. pp. 229–257, Aug., 1921.)—The present paper gives a complete account of measurements in the extreme ultra-violet of the spark spectra of a large number of metals. Preliminary accounts of the work have previously been given [Abs. 439, 442, 1067, 1068, and 1441 (1921)]. The wave-length tables now given include McLennan's results for comparison. A full description of the experimental arrangements and method is given, and typical spectrum photographs are reproduced. A. W.

1984. *Second Positive Group of the Band Spectrum of Nitrogen.* **P. Zelt.** (Zeits. wiss. Phot. 21. pp. 1–27, July, 1921.)—Following a brief general discussion of the band spectrum of nitrogen, a description is given of the second positive group. Experiments are then described on the dependence of the intensity of the nitrogen bands on pressure, but no variation due to differences in pressure was observed. Measurements of the different band lines are given, and these are discussed with reference to Deslandres' laws. A. W.

1985. *Quantum Theory and the Number of Dispersion Electrons.* **R. Ladenburg.** (Zeits. f. Physik, 4. 4. pp. 451–468, 1921.)—The absorption of isolated spectral lines is, according to the classic electron theory, characterised by the oscillation frequency ν, the damping constant ν' (Voigt's notation), and particularly by the number N of the dispersion electrons per unit volume. On the other hand, according to the quantum theory, absorption arises through change of the molecule from the condition i to the condition k, and the strength of the absorption, as follows from Einstein's work [Abs. 654 (1917)], and as Füchtbauer has calculated from his absorption measurements on the alkaline vapours [Abs. 1424 (1920)], is determined by the probability of the change i to k. From measurements of emission, absorption, dispersion, and magnetic rotation the number N of the dispersion electrons is given by the formula $N = N_i a_{ki}(g_k/g_i)(mc^3/8\pi^2 e^2 \nu_{ik}^2)$, where N_i is the number of electrons in the condition i, a_{ki} the probability of the spontaneous change k to i, which the oscillation number ν_{ik} causes, and g_k and g_i are the static weights of the corresponding states. The approximate agreement of N, for the first member of the alkali principal series, with the atomic number, shows that the mean life of the atom in the condition $2p$ is approximately equal to $3mc^3/8\pi^2 e^2 \nu^2$, that is, it corresponds on the "resonator" theory to the oscillation number $(1 \cdot 5s - 2p)$. In this state the atom (like a monochromatic resonator) can only emit this one oscillation. The decrease of the value of N with increasing term number of a series involves the decrease of the probability a_{ki}. This decrease consequently points to the conclusion that the number of different possible changes of state increases with increasing term number. The ratio $N_{D_2}/N_{D_1} = 2$ for the two D-lines, assuming equal mean duration for both initial conditions or states, signifies that the condition $2p_2$ is twice as probable as the condition $2p_1$. A. W.

1986. *Ratio of the Sodium D-Lines.* **R. Ladenburg.** (Zeits. f. Physik, 4. 4. pp. 469–472, 1921.)—An examination of the intensity ratio of the two D-lines, as determined by numerous observers by many different methods, shows that they all yield the integral value 2·0 (within the limits of error), and this value is independent of the temperature (between 170° and 1800° C.), the vapour density (varied in the ratio $1:10^5$), and the pressure (between 10^{-6} and 3 atmos.). This result corresponds to the ratio of the number of dispersion electrons [see preceding Abs.] for the two lines. A. W.

1987. *Critical Potentials and Spectra of the Nitrogen Bands.* **L. and E. Bloch.** (Comptes Rendus, 173. pp. 225–227, July 25, 1921.)—The authors have previously [see Abs. 1281 (1920)] described an arrangement for determining directly by spectroscopic means the potentials of resonance or of emission of gas. The principle of the method consists in photographing the spectrum of the light emitted, under the effect of electronic shocks, by the gas enclosed under very low pressure in a lamp of special type. The lamp has an incandescent tungsten filament, which serves as kathode, and a metallic grid which acts as anode. By increasing gradually the p.d. between kathode and anode a critical potential is reached for which the shocks of the electrons against the molecules are sufficient to make the rays determined appear upon the plate. It is by this means that the potential of appearance of the spectra of the positive bands of nitrogen (second group of Deslandres) has been fixed in the neighbourhood of 12 volts, that is to say well below the ionisation potential (18 volts about). It seemed important to try to find out if the spectra of the negative nitrogen bands arise in the same conditions as the positive spectra or, if, on the contrary, as different spectroscopic observations have suggested for some time, these two spectra have different vehicles and, correspondingly, involve expenditure of unequal amounts of energy. To decide this point, attention is devoted to the ultra-violet band 3914 Å. which is the more intense of the negative spectra of nitrogen. Under potentials of the order 30 volts, the band 3914 appears regularly and with an intensity much superior to that of the positive bands which frame it. It appears that the critical potential is well defined and is estimated to be about 21·5 volts; this value is considered to be correct within 0·5 volt. This shows that the spectra of the negative bands of nitrogen appear at an excitation potential very much higher than the positive spectra and slightly higher than the ionisation potential generally admitted for this gas. It appears natural to attribute the spectra of the positive bands of nitrogen to the neutral molecule N_2, and the spectra of the negative bands to the positively-charged molecule N_2^+. A. E. G.

1988. *The Balmer Series of Hydrogen.* **E. Gehrcke and E. Lau.** (Ann. d. Physik, 65. 6. pp. 564–576, Aug. 30, 1921.)—An investigation was made of the intensity distribution in the lines H_α, H_β, and H_γ, and the results are shown in photographs and diagrams. In agreement with Wood, it was found that the Balmer-series lines are more easily excited when water-vapour is present, the many-lined spectrum being more easily obtained in dry hydrogen. This fact affords evidence that the carriers for the Balmer series and for the many-lined spectrum are different. The research showed that the intensity ratio of the two components of, *e.g.*, H_α depends on the nature of the light source and method of excitation. This is shown by a photograph of the interference bands of H_α under different conditions. Similar intensity variations, but of smaller magnitude, were found in the case of H_β. Under similar conditions, if the intensities of the two components of H_α were the same, those of H_β were also equal; if the ratio of intensities for H_α was 1·5, for H_β it was only 1·1. The intensity ratio of the components of H_γ did not vary appreciably. A. W.

1989. *Time Interval between Absorption and Emission of Light in Fluorescence.* **R. W. Wood.** (Roy. Soc., Proc. 99. pp. 362–371, Aug. 2, 1921.)—In the case of the fluorescence of mercury vapour the author has succeeded in measuring the time interval between the absorption of light and the emission of the fluorescent light. For this a specially designed synchrono-phosphoroscope was used, and the experiments with this showed that the mercury vapour remained non-luminous during the process of the absorption of light, bursting into luminosity about 1/15,000th of a second later. A number of other substances were examined, and the experiments with barium platinocyanide showed that the time interval in this case must be less than 1/400,000th of a second. Further experiments with barium platinocyanide, using the method of Abraham and Lemoine, showed that the time interval for this substance must be less than 10^{-7} sec. A. W.

1990. *The Glow of Phosphorus.* **Rayleigh.** (Roy. Soc., Proc. 99. pp. 372–384, Aug. 2, 1921.)—This paper deals with the intermittent or periodic luminosity observed to be propagated through the gas space when the last traces of oxygen are being removed from air by means of phosphorus, or when air is allowed to leak slowly into an exhausted vessel containing phosphorus. It is shown that this effect, as ordinarily observed, requires the presence of water-vapour. Moderate drying (*e.g.*, by sulphuric acid) makes the glow perfectly steady. Water-vapour has, therefore, the power of inhibiting the combination of phosphorus vapour and oxygen within certain limits. When the composition of the mixture becomes favourable beyond those limits, a wave of combustion is propagated. Other substances are known to inhibit the glow of phosphorus. Some of these can be used to exhibit the above phenomena in a far more striking form than water. Camphor, ammonia, and pear oil are among the most effective, and experiments with these are described in detail. It is shown that the propagation of these waves of combustion cannot be attributed to the rise of temperature of one layer igniting the next layer, for the rise of temperature is too small. An alternative theory of the propagation is proposed, which assumes that it depends on the provision of nuclei, as in the propagation of crystallisation through a supercooled liquid. On this basis a theory of the action of the inhibitors (sometimes called "negative catalysts") is developed. A. W.

1991. *Excitation Stages in Open Arc-Light Spectra,* I. (*Na, K, Ca, Sr, Ba, Mg*). **B. E. Moore.** (Astrophys. J. 54. pp. 191–216, Oct., 1921.)—By using high potentials it is possible to lengthen the arc so that the middle region is well separated from the poles, and to reduce the current until few or none of the fundamental spectrum lines of the substance under observation are emitted. Evidently this arc affords a valuable means of studying the relative behaviour of spectrum lines. Using currents of from 0·03 to 0·3 amp. from a 2000-volt d.c. dynamo, the author made visual observations of the *variation of spectrum with current*, supplemented by measurements of the intensities of many lines. The results for each of the above-mentioned elements are reported in detail. *Five stages of excitation* were distinguished. Stage I: Lowest-current lines, which extend across the arc; generally resonance lines; including the first member of the principal doublet series of Na and K and of the principal singlet series of Ca, Sr, and Ba. Stage II: Coming in with slightly higher currents; relatively weaker in the middle of the arc; generally ionisation lines; including the diffuse and sharp subordinate series of Na, K, Ca, Sr, and Mg and the *p*-series of Ba. Stages III and IV each require a considerably greater current and each has considerably higher ratios of intensity at negative pole to that at positive pole and to middle intensity than the preceding stage. Stage V includes lines which failed to appear at all in the arc. Some bands were also

observed coming in at early stages. It was found that the ***ionisation lines of impurities*** such as Na appeared only when the ionisation potential of the main element in the arc was greater than that of the impurity. These results will be summarised and discussed in Part II, to follow.
AUTHOR.

1992. *Continuous X-Ray Spectrum.* **H. Behnken.** (Zeits. f. Physik, 4. 2. pp. 241–253, 1921. From the Physikal-Techn. Reichsanstalt.)—In support of the measurements of Ulrey the author, on theoretical grounds, deduced the following formula for the distribution of energy in the continuous X-ray spectrum : $E_\nu \nu^2/c = Q\nu \exp 2\cdot8[1 - \epsilon^{-q}(\nu_0 - \nu)/\nu^{2\cdot8}]$, in which $\nu \times 10^{18}$ is the X-ray frequency, E_ν the energy at the frequency $\nu \times 10^{18}$, c the velocity of light, $\nu_0 \times 10^{18}$ the highest frequency in the emission spectrum, and Q and q are constants. Using a tungsten antikathode q is approximately equal to 3·6. A factor $\epsilon^{-\mu_\nu d}$ is introduced to allow for the absorption of the glass walls of the X-ray tube, where μ_ν is the absorption coefficient of glass at a frequency $\nu \times 10^{18}$, and d the thickness of the wall. For the tube used in Ulrey's experiments $\mu_\nu d = 68\cdot0/\nu^{2\cdot8}$, the thickness of the glass being approximately 0·88 mm. [See Abs. 668 (1921).] A. B. W.

1993. *Fine Structure of X-Ray Spectra. II. L-Series. III. M-Series.* **A. Smekal.** (Zeits. f. Physik, 5. 1. pp. 91–106, and 5. 2 and 3. pp. 121–129, 1921.)—*Part II. L-Series.*—It has been found possible to arrange in a scheme all the X-ray lines ascribed to the tungsten L-series. This scheme renders necessary the existence of at least five M-" niveaus " through each of which a pair of well-known lines appear. This number indicates the necessity of a statement of the quantum relations of each electron shell by means of three quantum numbers, of which the " Azimuthalquanttum " can never become zero.

Kossel's explanation of K_β has been confirmed, and in addition an explanation has been given of all the K- and L-lines of tungsten which have not previously been interpreted. The relations $K_\beta - K_{\beta'} = L_\phi - L_\gamma$, $K_\beta - K_a = L_\phi + L_1 - L_3$ have been shown to apply over an extended range of elements, the agreement being perfect, within the limits of experimental error.

Part III. M-Series.—A proof of the relation $M_\gamma = L_3 - L_1 - (L_\phi - L_\gamma)$ has been given for an extended range of elements. A. B. W.

1994. *Soft Characteristic X-Rays from Arcs in Gases and Vapours.* **F. L. Mohler** and **P. D. Foote.** (Washington Acad. Sci., J. 11. pp. 273–274, June 19, 1921.)—If an electron current is maintained by a potential V between a hot kathode and an anode in a vapour at low pressure, then as V is increased successive changes occur in the spectrum excited by electron impact. The highest frequency ν of each additional group of lines is related to the least potential required to excite the group by the quantum equation $Ve = h\nu$.

The authors have studied the stages in the discharge by measuring the photoelectric effect of the radiation on two other electrodes entirely shielded from ions produced in the arc. This photoelectric current when plotted as a function of the exciting voltage shows nearly a linear relation, with changes of slope at critical potentials. In this manner potentials have been found which are determined by the limiting frequency of the softest X-ray series of a number of elements. The results obtained are included in the following table :—

SOFT X-RAYS FOR LOW-VOLTAGE ARCS.

Element.	Observed Potentials, Volts.		λ in Å.U.		Computed λ.
	a	*b*	*a*	*b*	L_{α}
Sodium	35	17	353·0	726·0	—
Magnesium	46	34	268·0	363·0	263·0
Phosphorus	126	99	98·0	125·0	92·2
Sulphur	152	121	81·2	102·0	77·2
Chlorine	197	156	62·7	79·1	61·9
Carbon	272	—	45·4	—	—
Nitrogen...............	375	—	32·9	—	—
Potassium	23	20	536·0	617·0	—

The preliminary results obtained emphasise the value of the method in studying radiations in the region between the range of the vacuum spectroscope and that of the X-ray crystal spectrometer. A. B. W.

1995. *Distribution of Electrons in Heavy Atoms.* **A. Dauvillier** and **L. de Broglie.** (Comptes Rendus, 173. pp. 137–139, July 18, 1921.)—In a previous paper [see Abs. 1776 (1921)] one of the authors has described a detailed investigation of the L-series of uranium, proposing a scheme for the sources of energy in heavy atoms. Employing the measurements of Coster and of Duane and Patterson, the authors, on the basis of this scheme, have calculated the magnitude of the majority of these sources, for tungsten and uranium, and have determined the corresponding Moseley numbers. A. B. W.

1996. *Diffraction of X-Rays by Liquids.* **A. Debierne.** (Comptes Rendus, 173. pp. 140–142, July 18, 1921.)—By a transmission method similar to that of Laue for the X-ray examination of crystal laminæ, the authors have demonstrated a simple structure in certain liquid layers. Photographic records of the X ray beam transmitted through a liquid layer show, in certain cases, two distinct annuli, which suggest a simple "crystalline" arrangement of the atoms in the liquid layer. The phenomenon has been observed with the following liquids :—Mercury, methyl iodide, methylene iodide, benzine, bromobenzene, etc., and some mixtures. The phenomenon is analogous to that in which the annuli are produced with irregular masses of crystals or with powdered crystals, and with certain so-called "amorphous" substances. A. B. W.

1997. *Precision Measurements in the L-Series of Heavy Elements.* **D. Coster.** (Zeits. f. Physik, 4. 2. pp. 178–188, 1921.)—Tabulated results are given of a series of precision measurements for the elements, tungsten and uranium. A new L-doublet has been measured, and the observations show that the Δ-doublet does not exist. The probability of the existence of a very weak line β_7 has been demonstrated, this line being of considerable theoretical importance. A. B. W.

HEAT.

1998. *Gas Thermometer Measurements between* − 193° *and* − 258° C. **F. Henning.** (Zeits. f. Physik, 5. 4. pp. 264–279, 1921. From the Physikal.-Techn. Reichsanstalt.)—The observations given in the paper were made in 1913 and 1914. Their publication was withheld because the measurements with the constant-density helium thermometer gave a value for the pressure coefficient of this gas which appeared not to be in agreement with the ordinary equation of state, assuming the melting-point of ice to be 273·09° abs. In 1920, however, extensive investigations on the mean coefficient of expansion, α, and the mean pressure coefficient β between 0° and 100° C. of helium, hydrogen, and nitrogen gave the following results, where p_0 = pressure of gas at 0° C. in metres of mercury :—

Helium .. $107\alpha = 36604 - 19p_0$; $107\beta = 36604 - 4p_0$.
Hydrogen .. $107\alpha = 36604 - 12p_0$; $107\beta = 36604 + 10p_0$.
Nitrogen .. $107\alpha = 36604 + 127p_0$; $107\beta = 36604 + 134p_0$.

The experiments indicated that the absolute temperature of the melting-point of ice = 273·20°. Hence the values obtained in 1913, 1914, for the pressure coefficient of helium are confirmed, and the doubt as to the correctness of the gas thermometer measurements is removed.

A comparison has been made of the helium and nitrogen thermometers with the same platinum thermometers as were employed in 1912 between 0° and − 193° C., and also with the hydrogen thermometer. Hence it was possible to fix the differences in the readings of the various gas thermometers. Moreover, since the measurements with the helium thermometer were carried to − 258° C., the calibration of the platinum thermometer was extended to lower temperatures than had previously been done. This enabled the series of previously obtained fixed points for the boiling-point of hydrogen to be extended. Finally the resistances of copper, lead, and tungsten at the temperatures of liquid air and liquid hydrogen were obtained by comparing " resistance thermometers " of these metals with the helium thermometer. The values found for the boiling-points of hydrogen and oxygen agree very closely with the results obtained by Kamerlingh Onnes. Practical details and numerous tables of results accompany the paper. T. B.

1999. *Experiments on Thermal Diffusion ; Confirmation of Chapman's Theory.* **T. L. Ibbs.** (Roy. Soc., Proc. 99. pp. 385–395, Aug. 2, 1921.)—It has been shown by Chapman both theoretically and experimentally [see Abs. 513 (1917)], that a temperature gradient applied to a uniform mixture of two gases will cause a separation of the gases, the smaller and lighter molecules diffusing towards the hotter side (" thermal diffusion ").

Experiments are now described in further confirmation, by a new method, of Chapman's theoretical work. The gas used was a mixture of various proportions of hydrogen and carbon dioxide. The gases were analysed, before and after thermal diffusion had taken place, by means of a " katharometer," the action of this instrument depending on differences of thermal conductivity of gases or mixtures of gases. The max. separation obtained in the experiments was 3·52 % for a mixture of 61 % H and 39 % CO_2 for a temperature difference of 557 deg. C. The amount of separation was found to be proportional to log T_1/T_2, where T_1 and T_2 are the absolute temperatures forming the temperature gradient. This is in agreement with Chapman's formulæ.

S. Chapman. (Roy. Soc., Proc. 99. pp. 396–397, Aug. 2, 1921.)—Ibbs's experiments referred to above are found to agree with the theoretically predicted formula—

$$k_t = (0{\cdot}331\lambda_1 + 0{\cdot}0542\lambda_2)/(47{\cdot}2 + 86{\cdot}5\lambda_{1.2} + 5{\cdot}58\lambda_{2.1}),$$

where k_t is the coefficient of thermal diffusion, λ_1, λ_2 are the percentages by volume of CO_2 and H respectively, $\lambda_{1\cdot2} \equiv \lambda_1/\lambda_2$ and $\lambda_{2\cdot1} \equiv \lambda_2/\lambda_1$. The absolute amount of separation found by Ibbs is a good deal less than that required by the theory, which was deduced, however, on the assumption that the molecules are rigid elastic spheres. T. B.

2000. *Specific Heat of some Metal Sulphides (Pb, Cu, Fe, Zn) at High Temperatures.* **K. Bornemann** and **O. Hengstenberg.** (Metall u. Erz. 17. pp. 313–319, July 20, and pp. 339–349, Aug. 8, 1920. Rev. de Mét. 18 E. pp. 391–392, July, 1921.)—The specific heats are wanted for metallurgical calculations. The method used is a modification of Oberhoffer's: a tubular furnace and a Bunsen ice calorimeter are so combined that they form a vertical tube, and this is evacuated; the sample is dropped into the calorimeter. The ice calorimeter was replaced by a calorimeter such as used by Nernst, Lindemann, and Magnus, and a special device (comprising two metallic mirrors and a solenoid) was adopted to close the top of the furnace and to keep the radiations off the calorimeter. The spiral carbon furnace has a height of 200 mm. and an internal diameter of 20 mm. The specimen is dropped into a hollow block of aluminium placed in a Dewar vessel; the rise of temperature in the block is measured by a thermopile of 24 copper-constantan junctions, fitting into holes of the block, alternately 75 and 55 mm. deep, arranged on two concentric circles. The disintegrated sample is placed in a quartz tube, 7 cm. long, 8 mm. diameter, 0·6 mm. wall thickness, provided with a stricture. The mean specific heat of quartz, first determined, was found to be 0·1883 between 0 and 100°, and 0·2610 between 0 and 1400°; these values agree best with those of Magnus. In the case of sulphides (Pb, Cu, Fe, Zn) the temperatures could not be pushed so high, and the heat of fusion not be determined, because sulphur was liberated. In galena the specific heat rose regularly (up to 600°) from 0·0500 to 0·0540. In synthetic CuS (up to 1050°) the mean specific heat varied, 0·1432 (100°), 0·1690 (300°), diminishing then more regularly to 0·1369. In iron sulphide the specific heat decreased with increasing sulphur percentage from 0·17 for FeS to 0·128 for FeS_2, between 0 and 100°, but there was no proportionality and the minerals were not quite pure; the highest value observed was 0·2216 at 1200°. Three samples of zinc blende (christophite, blende from Ems and from Annam) all showed an increase in the specific heat at higher temperature, the christophite from 0·1249 to 0·1351 at 900°, and further a sudden drop between 720° and 760°, indicating a new transformation, which was otherwise confirmed and is probably due to the presence of iron. H. B.

SOUND.

2001. *Reason for a Limit to Audibility.* **V. Cheval.** (Soc. Belge Élect., Bull. 35. pp. 55–72, March–April, 1921.)—From a careful examination of the anatomy of the human ear, detailed in 12 figures and diagrams, it is claimed as a mechanical consequence (1) that less than 16 complete vibrations per sec. will not be able to produce a continuous sound, and (2) that more than 32,760 complete vibrations per sec. will be inaudible. The higher limit is obtained as corresponding to a half-wavelength of 25·96 mm. which is approximately the length of the basilar membrane. (The speed of sound in the liquid of the internal ear being taken as 1700 m. per sec.) E. H. B.

2002. *Absolute Measurement of Sound.* **A. G. Webster.** (Engineering, 111. pp. 763–765, June 24, 1921. Discourse delivered before the Roy. Inst., June, 1921.)—This discourse gave a summary of studies upon which the author entered some thirty years ago under Helmholtz. The author's own particular object was to devise a reproducible instrument capable of measuring, in absolute units, the sound intensity at any point in space. One of the chief difficulties of the problem lies in the extreme minuteness of the forces and energies involved. The energy put into foghorns was considerable, but the estimates of their outputs differed widely. The energy output of musical instruments was very low. It would take ten million cornets playing *fortissimo* to emit one horse-power of sound. The author's own voice, when speaking in a loud tone, did not in any part of the lecture room (except close to the mouth) produce pressure variations of more than a few millionths of an atmosphere.

The author's investigations have resulted in his *phonometer* by which quite feeble sounds can be dealt with. The sensitive part is a diaphragm of glass, mica, etc., and displacements down to 1/24,000 mm. can be detected by interferometry. For full details the paper should be consulted, which gives twelve diagrams in illustration of the phonometer, also a very full description. E. H. B.

2003. *Sound Waves in the Atmosphere.* **E. A. Milne.** (Phil. Mag. 42. pp. 96–114, July, 1921.)—This paper deals with the kinematics of the propagation of sound waves through a medium such that the speed of the medium and of the sound in it varies from point to point. The subject arose in connection with the location of aircraft by sound. The direction determined by a direction-finding instrument is not in general that of the source, corrections being required for the convection and refraction undergone by the sound-waves in their passage through the atmosphere. The necessary approximate formulæ were first given by A. V. Hill. The present investigation was originally started to examine in detail the errors in Hill's approximation, but those results, of technical interest at the time, are not considered of sufficient general interest for insertion here, the treatment being more general. The very interesting results obtained are exhibited in a number of graphs, and the original paper should be consulted for details. E. H. B.

2004. *Musical Sounds from Heated Metals.* **B. N. Chuckerbutti.** (Indian Assoc. for Cultivation of Sci., Proc. 6. Pts. 3 and 4. pp. 143–154, 1921.)—This paper describes an experimental study and a theoretical discussion of the vibrations of the Trevelyan rocker, and the manner in which the musical tones arise. A method is described by which the vibration curves at different parts of the rocker may be observed and photographed, and numerous illustrations are reproduced. The theory of the rocker, worked out mathematically by Davis (Phil. Mag. vol. 54. p. 296, 1873) is critically discussed, and it is shown that the basis on which it rests, namely, that the motion of the heated bar is a simple rocking about the two edges under the action of gravity, is contradicted by observations on the amplitude and frequency of the vibration of the rocker. The outcome of the research is to show that the musical tones arise principally from the elastic vibration of the system composed of the rocker and its handle, and their pitch is determined by those vibrations. As the vibrations occur under constraint, the pitch may vary to some extent with the experimental conditions. The effect of pressure on the rocker in raising the pitch is similarly explained. Eighteen photographic reproductions of the vibrations are included in the paper. E. H. B.

2005. *Æolian Tones in Air and Water.* **E. F. Relf.** (Phil. Mag. 42. pp. 173–176, July, 1921.)—The object of these experiments was to investigate the cause of the musical note heard when a wire of circular section is moved through air at a considerable speed. It was suspected that the frequency of the note was that of the periodic eddy formation behind the wire, and that the note was, consequently, independent of the tension in the wire and of its elastic constants. Experiments were made in a small water channel, of cross-section 5 in. by 3 in., in which steady speeds up to a little over an inch per sec. could be obtained. Cylinders of various diameters were put in the stream and the eddy period was measured by a tethered bit of paper used as an indicator and capable of both swing and rotation. Experiments were next made upon five wires in air by means of an electric motor which carried the wire round in circles of known radius and therefore with known speed (the frequency of the motor being known). From dimensional theory it can be shown that $nD/V = f(VD/\nu)$, where n is frequency of eddies per sec., V the speed, D the diameter of the wire, and ν the kinematic viscosity of the fluid. So nD/V was plotted against VD/ν, and gave the same graph for water and for air. No note is emitted, for $VD/\nu < 100$. E. H. B.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

2006. *The Quenching of Tin Brasses.* **L. Guillet.** (Rev. de Mét. 18. pp. 445–458, July, 1921.)—[See Abs. 1626 (1921).]—A series of alloys containing 60 % Cu and 0 to 5 % Sn was examined. The solubility of tin in α brass increases with the Cu content. Tin brasses containing 60 % Cu show a constituent similar to the δ compound in bronzes. This increases with the tin content, but can be removed, for lower tin contents by annealing, for higher by quenching from 600° C. ; 800° C. is too high for good results. For the 1 % tin alloy quenching from 600° C. gives the following increases over annealing : ultimate, 10 kg. per mm.^{2} elastic limit, 8 kg. ; elongation, 24 % ; Brinell hardness, 25. More than 1 % tin does not improve brass from a mechanical point of view.
J. L. H.

2007. *Thermal, Electrical and Magnetic Properties of Alloys.* **A. W. Smith.** (Frank. Inst., J. 192. pp. 69–105, July, and pp. 157–202, Aug., 1921.)—The liquidus curves for a large number of binary alloys are collected and compared with other physical properties, *e.g.*, thermoelectric power, conductivity. Five cases are considered—(1) the two components are not soluble in each other and form no chemical compounds ; (2) the two components are mutually soluble in all proportions ; (3) each component is soluble in the other to a limited extent ; (4) the two components form a compound which forms mechanical mixtures with each component ; (5) the components form one or more compounds which are soluble to some extent in each component and each other.

Some theories dealing with the physical properties of alloys are considered.
J. L. H.

2008. *New Method for the Investigation of the Adsorption of Gases by Solid Bodies.* **R. Seeliger.** (Zeits. f. Physik, 4. 2. pp. 189–194, 1921.)—The absorption (adsorption) of gases by solid bodies has received much attention, the most recent novelty [see Abs. 1863 (1907)] being from the mineralogical standpoint, whereby certain crystallised aluminium silicates were found to possess the remarkable property of absorbing gases after the expulsion of their water of crystallisation. In these cases the interior of the crystal appears to play a highly interesting part in the absorption. Previous work has been carried out by the well-known volumetric method, which, however, involves the disadvantage of having to use considerable amounts of the absorbing body, also of all the inaccuracies of gas determinations. The present paper describes a new method which is free from most of the objections inherent in the older processes. The fundamental idea is very simple and is based neither on the volume nor the weight of the absorbed gas but on its inert mass. If the inert mass of the absorbing body be determined before and after absorption, then the difference will be the mass of the absorbed gas. This determination may be made accurately by measurement of the torsional vibration frequency, and the great advantage is obtained of being able to use very small quantities of the absorbing body. Sources of error are discussed and experimental details with observation results are given. H. H. Ho.

2009. *Combustion Cells for High Temperatures.* **E. Baur, W. D. Treadwell,** and **G. Trümpler.** (Zeits. Elektrochem. 27. pp. 199–208, May 1, 1921.)—Kathodes of iron oxide are preferable to copper oxide kathodes [see Abs. 658, 659 (1919)], because iron, sufficiently flushed with air, assumes a potential higher by 0·2 volt, this being due [Sosman and Hostetter, Abs. 1032 (1917)] to the fact that Fe_2O_3 and Fe_3O_4 form a continuous series of homogeneous mixtures of variable dissociation-pressure and potential, the potential approaching the air potential at the respective temperature. Electrodes of iron oxides are depolarised by air, which should have ready access; the granulated oxide is hence provided with a porous diaphragm (magnesia), which absorbs the electrolyte (fused alkali carbonate). Several cells are described. In the tubular arrangement iron gauze (anode) is wrapped round a rod and placed within a tube of magnesia, which leaves an annular space for air circulation between the magnesia and iron. Outside is a mixture of coke and soda, and the whole is inserted in a tube of iron, which is heated to 800° or higher. In the gas cell two tubes of magnesia, closed below, are placed in a crucible charged with fused soda; the tubes are lined inside with gauze; air is passed into the one tube, and coal gas (also CO or hydrogen) into the other. Bricks of magnesia and specially-prepared porous magnesia stones ("wick-cells") are also used in various modifications. These combustion cells are considered technically possible, though of doubtful economy owing chiefly to the high temperatures required. H. B.

2010. *Action of Electrolytic Valves; Tantalum Electrodes.* **A. G. Schulze.** (Ann. d. Physik, 65. 3. pp. 223–246, June 14, 1921. From the Physikal.-Techn. Reichsanstalt.)—During the formation of electrolytic valves the p.d. rises first to the spark potential (gradient *a*), then to the max. potential (smaller gradient *b*), and there may be a further slight rise (gradient *c*). On the anode there are formed a solid, porous film of thickness Δ (oxide or compound), and another film of high electrostatic capacity and thickness δ (effective gas film, oxygen). Both the films are exceedingly thin, especially the latter; δ can only be estimated assuming the dielectric constant of the film to be about 1, which appears to be justified. Tantalum is preferable to other metals, including Al, as anode material, because the films formed on Ta are insoluble, and the interference colours, on which the thickness estimates of Δ and δ are based by the author, are pure; particulars of these estimates are given. Tantalum is, however, exceedingly sensitive to contact with other metals and with hydrogen, which it readily absorbs under formation of a brittle compound; all accidental contact between the highly-polished tantalum and insoluble or passive metals like platinum and iron, and contamination with hydrogen (kathode or merely heating in the Bunsen flame) should hence be avoided; otherwise the formation of the electrode may be delayed or fail altogether for reasons not yet understood. The author's tantalum (from Siemens and Halske) consisted of a rod (4 mm. thick, 200 mm. long), and a foil (of 15 by 60 by 100 mm.). The formation of the two films and the generation of oxygen go parallel. Studying the gradient *a*, in volts per minute, at 25 to 150 volts, in a large number of electrolytes under various conditions, and further the degree of formation, *i.e.*, the fraction of the formation current which serves for building up the films, he finds that the film formation becomes more and more difficult as the temperature rises to 100°, when more oxygen is liberated, and that the electrolytes may be divided into three groups. In the first group [H_2O_2, $KAg(CN_2)$] the gradient *a* increases as the potential is raised; in the second group (KNO_3, H_2SO_4, sodium heptylate, etc.) *a* is constant; in the third group (KCN, $NaOH$, $Na_2B_4O_7$, $NaPO_3$, etc.) *a* decreases; in the first group the *a* are largest, in the third smallest. The differences cannot be explained; tantalum is insoluble in all the electrolytes used. H. B.

2011. *Factors Governing the Structure of Electro-deposited Metals.* **W. Blum.** (Am. Electrochem. Soc., Trans. 36. pp. 213–232; Disc., 232–241, 1919.)—The experiments here described were carried out with a view to testing the following axioms concerning electroplating laid down by Bancroft. (1) Bad deposits are due to excessive admixture of some compound or to excessively large crystals. (2) Excessive admixture of any compound may be eliminated by changing the conditions so that the compound cannot precipitate. (3) Increase of the current density, or increase of the p.d. at the kathode, or depression of the temperature decreases the size of the crystals. (4) The size of the crystals is diminished when substances adsorbed by the deposited metal are present at the kathode surface. (5) If a given solution will yield a good deposit at any given current density, it will yield a good deposit at any higher current density provided that the conditions at the kathode surface are kept constant. (6) Treeing is facilitated by a high fall of potential through the solution and by conditions favourable to the formation of large crystals.

It is found that these axioms are applicable over a wide range of conditions, and to a variety of metals. A number of recommendations are made as to the composition of the solutions, the current density, and the temperature best suited to the formation of satisfactory deposits. T. H. P.

2012. *Structure of Metal Electro-deposited upon Rotating Kathodes.* **W. E. Hughes.** (J. Phys. Chem. 25. pp. 495–509, June, 1921.)—The various explanations of the "polished" appearance often observed with metallic deposits formed upon rotating kathodes are discussed and the suggestion is made that such appearance is due to the smallness of the grains composing the deposit. This smallness of the grain appears to be the result of constancy of the concentration of the metal at the surface of the kathode, and this constancy to be the result of the movement of the kathode and not of any burnishing action, as has been suggested. T. H. P.